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ABSTRACT

Hyponatremia (severe sodium depletion) has symptoms similar to heat exhaustion and heat stroke and can easily be misdiagnosed. The number of wilderness users and extreme adventure activities has increased in recent years, and more cases are being diagnosed. Given that a 1993 study found that 1 in 10 cases of heat-related illnesses were hyponatremia, wilderness medicine providers need to become familiar with this illness. In hyponatremia, as sodium decreases in relation to water, water moves from the cardiovascular system into the intracellular space in the brain, which can result in cerebral edema followed by seizures, coma, and death. Symptoms of hyponatremia that differentiate it from heat exhaustion and heat stroke are decreased thirst, increased urine output and frequency of urination, clarity of urine, lack of poor skin turgor (tenting of the skin), and moist mucous membranes. Patients with hyponatremia may have a significant decrease in level of consciousness, but will not have hot skin or a high core body temperature. Hyponatremia often occurs after the strenuous activity has ceased, while heat exhaustion and heat stroke occur during the activity. Knowledge of patient activity level and duration, food and water intake, medical history, and medications are extremely important. Treatment of hyponatremia in the wilderness includes rest, maintaining a stable core body temperature, withholding fluids, and increasing sodium intake (in conscious patients). Two charts present an algorithm for the assessment of heat illnesses and a comparison of symptoms for heat exhaustion, heat stroke, and hyponatremia. (Contains 11 references.) (TD)

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"DEHYDRATION, HEAT STROKE, OR HYPONATREMIA? THE RECOGNITION, TREATMENT, AND PREVENTION OF HYPONATREMIA CAUSED BY HIGH EXERCISE OUTDOOR ACTIVITIES"

Brent Cochran

ED 443 633

Abstract

Hyponatremia (severe sodium depletion) is a wilderness medicine issue in the management of heat emergencies such as heat exhaustion/dehydration and heat stroke and can easily be misdiagnosed. Inaccurate assessment of hyponatremia can result in the patient receiving incorrect care, which could exacerbate the illness, which can be fatal. The proper assessment, treatment, and prevention of hyponatremia can help outdoor leaders to implement safe, high quality trips, and avoid medical emergencies resulting from a lack of knowledge, experience, and trip leadership in high exercise outdoor activities.

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Hyponatremia is becoming recognized as an issue in the management of heat emergencies in wilderness medicine. Presently, the subject of hyponatremia is not covered in most Wilderness First Responder curricula. Hyponatremia is made up of complex pathophysiology and is not well understood in sports medicine or wilderness medicine.

Much of the research done on the subject of hyponatremia has been done in the field of sports medicine. One notable study in wilderness medicine was done in the Grand Canyon National Park in 1993.

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Hyponatremia has traditionally been observed as an issue secondary to other medical problems in patients. In more recent times, given the advent of more human endurance activities such as marathoning and ultra-marathoning, eco-challenges, and extreme mountaineering, hyponatremia has become a much more apparent problem in heat related emergencies. Thus, the issue of "Exercise-Induced Hyponatremia" has become more prevalent both in incidence and in research.

The terminology used in this article is standard medical terminology and should be familiar to Wilderness First Responders and EMTs. Potentially unfamiliar terminology is accompanied by brief definitions.

Humans evolved as a species in a warm, tropical environment. Therefore, we are generally better adapted to hot environments than cold environments. Some ethnic groups have further evolved to deal with specific climates over throughout the evolution process. Thin people, as opposed to heavy people, are better adapted to warm environments as they are better able to cool themselves due to the greater body surface area in relation to mass.

Humans are able to acclimatize to heat challenges over a period of 7-10 days and are particularly susceptible to heat injury if they are not acclimatized, are overweight, are in poor physical condition, have underlying medical conditions, take certain drugs, if they dress inappropriately, and if they overwork themselves in a hot environment.

Humans are faced with environmental challenges, especially in the outdoor adventure setting. The ambient temperature, wind, and atmospheric moisture (rain, snow, & humidity) play a major role the way humans deal with a hot environment.

Humans produce heat in a variety of ways. Some efforts are voluntary such as exercising. Other heat production processes are involuntary including shivering (thermogenesis) and hormonal releases of epinephrine and norepinephrine. Heat production processes are used to increase the body's basal metabolism (metabolism is the totality of the body systems working together to sustain life).

Heat conservation is accomplished in several ways including the abolition of sweating, vasoconstriction, and piloerection (goose bumps/hair standing on end).

Heat loss factors are induced by environmental challenges and consist of conduction, convection, radiation, evaporation, and to some extent, respiration. Heat moves to colder environments. An example of conduction occurs when persons are immersed in water, wear wet clothes, or are sitting on the cold ground. An example of convective heat loss is the effect of wind chill. Radiation occurs when heat moves away from the body into the surrounding air. More heat is radiated from the head than any other body area. Evaporation occurs when water on the skin converts from liquid to gas. Evaporation occurs upon sweating, depending on humidity levels, and upon getting wet from swimming and precipitation. Some heat is lost, particularly in cold and dry environments, during respirations.

The body's heat elimination processes include vasodilation, increased cardiac output and respiratory rate, decreased heat production, and sweating.

The nutrition and hydration needs of the body must be met in order to maintain homeostasis (normal body function). Food and water fuel the basil metabolism. The appropriate caloric intake must be matched to the individual's metabolic rate and activity level. The average person needs to intake 2000-2500 calories per day as follows: 10% protein, 30% fats, and 60% carbohydrates. A person may need to double or triple their caloric intake based on the environmental conditions and activity levels.

Hydration requirements also depend on activity levels and environmental conditions. The average person needs 2-2.5 liters of water per day. Activity levels and conditions may indicate a need to double or triple hydration.

Heat Exhaustion is essentially severe dehydration. It may include a depletion of fluids and electrolytes. Signs and symptoms of heat exhaustion include fatigue, dizziness, orthostatic hypotension (lower blood pressure/feeling faint, upon standing), chills, nausea/vomiting, malaise, and a general feeling of illness. There will be no significant increase in core body temperature. In most cases, heat exhaustion patients do not show significant alterations in LOC (Level Of Consciousness).

The treatment for heat exhaustion is rest and fluids. In most cases, oral fluids are sufficient. One teaspoon of salt and 1 tablespoon of sugar can be added to water to address electrolyte and glucose needs. In severe cases, intravenous fluids are required. If untreated, severe heat exhaustion can lead to hypovolemic shock. Heat exhaustion is easily corrected in most cases.

Heat Syncope is similar to heat exhaustion and is treated the same way. Syncope is a condition of fainting upon standing from a lying down/sitting position due a decrease in blood pressure (orthostatic hypotension).

Heat Cramps are also similar to heat exhaustion and are a result of a depletion of electrolytes. Cramps are treated in the same way as heat exhaustion.

Adjusting activity levels to the environmental conditions as well as the individual's physical condition, wearing appropriate clothing, managing nutrition and hydration needs, and resting often can prevent heat exhaustion problems.

Heat Stroke is a very serious, life-threatening thermoregulatory problem. Heat stroke, or hyperthermia, is an extreme elevation of the body's core temperature. Heat stroke usually results in brain damage and can be fatal. There are two forms of heat stroke, classic and exertional.

Classic heat stroke results from a continuous heat insult in which the body is no longer able to compensate through sweating and is a result of severe dehydration. Classic heat stroke is often seen in the elderly, homeless, mentally ill, and medical patients. In outdoor recreation, the individual who becomes dehydrated is at risk.

Exertional heat stroke is a result of the body producing more heat than it can eliminate. It is not a result of dehydration. This type of heat stroke is more common in high exercise activities.

Heat stroke patients will have red, hot skin, which may be wet (exertional) or dry (classic). LOC will be decreasing ultimately to seizures, coma, and death. The core body temperature is 105 degrees Fahrenheit or higher.

The treatment of either form of heat stroke is to cool the patient rapidly. Patients should be cooled with water, fanning, limb massaging, shade, etc. Heat stroke patients must be evacuated to definitive medical care as soon as possible; however, care should not be delayed in order to evacuate. Heat stroke can permanently alter the body's thermoregulatory function.

Hyponatremia is a problem in which the balance of water and sodium in the body is upset. It is caused by a significant depletion of the sodium in relation to water. In the human body, water follows sodium, and as sodium decreases, water moves osmotically (a form of diffusion...a fluid shift) from the cardiovascular system into the intracellular space (cells) in the brain. This can result in cerebral edema (swelling of the brain). Cerebral edema may result in seizures, coma, and death.

The human body is made up of approximately 60% water. Intracellular fluid (fluid within the cells) makes up about 75% of the water in the body while extracellular fluid (fluid outside the cells) makes up about 25% of the body's water. Extracellular fluid is made up of interstitial fluid (fluid between the cells...about 17.5%) and intravascular fluid (fluid within the circulatory system...about 7.5%)

Homeostasis exists when there is a balance between water and electrolytes. The four major elements that account for over 99% of the body's atoms are Hydrogen, Oxygen, Carbon, and Nitrogen. The trace elements, which make up less than 1% of the body's atoms are Calcium, Chlorine, Iodine, Iron, Magnesium, Phosphorous, Potassium, Sodium, and Sulfur.

Electrolytes are atoms or molecules which dissociate (break down) into electrically charged particles when placed in water. Sodium, Potassium, Calcium, and Magnesium are cations (positively charged ions) and Chloride, Bicarbonate, and Phosphate are anions (negatively charged ions). These cations and anions are the most frequently occurring electrolytes in the body.

Hyponatremia is caused by a decrease in the level of sodium relative to water. An increase in the level of sodium relative to water is hypernatremia.

Sodium and water move throughout the body in relation to tonicity (the relationship of the solute...sodium to the solvent...water). Cell membranes are semi-permeable. Solutions of equal tonicity on either side of a cell membrane are called isotonic. Solutions that have a higher solute concentration on one side of a cell membrane are considered hypertonic. Solutions that have a lower solute concentration on one side of a cell membrane are called hypotonic.

"Water follows sodium," so in a cell that is hypotonic in regard to the sodium level (lower concentration of sodium in the intracellular space compared to the extracellular space), water will diffuse (move) across the cell membrane into the cell, causing swelling of the cell.

The body will attempt to restore homeostasis by balancing sodium and water through spontaneous diuresis (urination). Should the body be unable to restore a balance, ultimately, cerebral edema may occur.

Hyponatremia may result when the body is in a state of dehydration, homeostatic hydration, or overhydration.

Hyponatremia can occur as a chronic problem and is usually secondary to other medical illnesses or psychiatric problems. Acute hyponatremia cases are seen among athletes and outdoor adventures and result from significant sweating and may be accompanied by excessive water intake along with a lack of sodium intake.

Some signs and symptoms will mimic heat exhaustion as well as heat stroke, while other signs will differ from either heat exhaustion or heat stroke.

The patient assessment system consists of the Primary Survey (to determine immediate life-threatening problems) and the Secondary Survey (to determine other problems which may or may not become life-threatening...all problems). Components of the secondary survey consist of the assessment of the (MOI) Mechanism Of Injury and Chief Complaint, a hands-on Patient Exam, AMPLE (Allergies, Medications, Past Pertinent Medical History, Last Oral Intake of Food & Water, and Events Leading Up To The Injury/Illness) Patient History, and check of the patient's Vital Signs.

Signs and symptoms of Hyponatremia that mimic heat exhaustion normal or increased respirations, normal or increased heart rate, pale, cool skin, normal or decreased

blood pressure, normal or decreased body temperature, normal or decreased capillary refill, ataxia, dizziness, headache, parathesias, chills, and nausea/vomiting.

Signs and Symptoms of Hyponatremia that mimic heat stroke are decreased LOC, increased heart rate, increased respirations, warm skin, decreased blood pressure, decreased capillary refill, seizures/coma, ataxia, dizziness, headache, normal & clear urine (exertional heat stroke), nausea/vomiting, and moist mucous membranes (exertional heat stroke).

There are several signs and symptoms of hyponatremia that can be used to differentiate it from heat exhaustion and heat stroke. Hyponatremia patients will exhibit decreased thirst and increased urine output, frequency of urination, and clarity of urine, lack of poor skin turgor (tenting of the skin), and moist mucous membranes. Patients with hyponatremia may have a significant decrease in LOC, however; they will not have hot skin and they will not have a high core body temperature. (See table "Comparison of Signs & Symptoms Heat Exhaustion, Heat Stroke, & Hyponatremia.")

In order to accurately assess hyponatremia, the care provider must first determine the patient's LOC. The rescuer must determine whether or not the patient has an increased core body temperature. Is it a thermoregulatory problem or a fluid/electrolyte problem? The rescuer must determine the history of the patient's fluid and food intake as well as the patient's urine output. Using these assessment tools, the rescuer can usually determine the type of heat illness from which the patient is suffering. See "Algorithm for the Assessment of Heat Illnesses.")

Hyponatremia will often present some time (1-3 hours) after the strenuous activity has ceased, while heat exhaustion and heat stroke present during the activity.

The patient history, particularly of activity level and duration, food and water intake, medical history, and medications are extremely important.

The treatment of hyponatremia in the wilderness medicine setting is to rest the patient, maintain a stable core body temperature, withhold fluids, increase sodium intake (in conscious patients), and maintain ABCs.

Withholding fluids will allow the body to eliminate water through spontaneous diuresis, and therefore, decrease the potential of cerebral edema. When the patient is able to swallow, small amounts of fluid containing significant electrolyte levels (primarily sodium) should be administered. Salty snacks can be given. Salt tablets should not be ingested; however, they can be dissolved in water. The patient must be monitored for potential vomiting.

When available, oxygen should be used. In cases of significant decrease in LOC, high-flow oxygen should be administered.

Advanced Life Support measures, which are not usually available in the wilderness setting, may include endotracheal intubation, intravenous access with normal saline (or hypertonic saline) administered at a "Keep Vein Open" rate, and the administration of the drug Valium TM (Diazepam), a sedative, to control seizures. ALS providers should also use a cardiac monitor, when possible.

Patients suffering from mild hyponatremia may self-resolve the problem through spontaneous diuresis. Patients who suffer severe hyponatremia (decreased LOC, seizures, or coma) should be evacuated immediately to definitive medical care, even if the problem seems to resolve itself.

Hyponatremia can be prevented by adjusting activity levels to environmental conditions, terrain, physical fitness levels, and by maintaining proper food and water intake. In order to maintain sodium levels, intake of typical trail food such as gorp, cheese, granola, and other salty foods is usually sufficient. In addition to sodium, potassium intake is

important in the maintenance of neuromuscular function. Carbohydrates/Sugar are converted into glucose which is necessary in order to prevent (or delay) metabolic exhaustion/fatigue.

Overhydration is a possibility, and outdoor adventurers should maintain good nutrition as well as hydration in order to maintain homeostasis.

A heat study was done in the summer of 1993 by the Grand Canyon National Park Emergency Medical Services in order to determine the impact that hyponatremia has on park visitors suffering from heat related emergencies.

The investigation into hyponatremia at the Grand Canyon prompted two articles, one being published in the Volume 4, Number 4 , 1993 issue of the Journal of Wilderness Medicine by Howard Backer, Ellen Shopes, and Sherrie Collins. Another article, detailing the heat study, was published in the December 1997 issue of the Journal of Emergency Nursing by Ellen Shopes.

The heat study found that approximately 90% of reported heat related problems were a result of heat exhaustion/dehydration, approximately 10% of problems were hyponatremia, and that less than 1% of the problems were heat stroke.

The Grand Canyon has specific environmental conditions such as extremely hot summer temperatures of 100+ degrees Fahrenheit, steep trails that descend several thousand feet from the rim to the river, and extremely low humidity.

This national park is one of the most heavily visited in the US, and it has some of the most extreme heat. While these are characteristics somewhat unique to the Grand Canyon, there are many other similar environments that wilderness users encounter. Therefore, it is a significant issue for outdoor adventurers.

In recent years, this illness has been increasingly studied in sports medicine as more cases are being diagnosed, particularly in endurance sports. This results from more persons being involved in these activities, as well as the perhaps the overzealous intake of fluids without significant electrolytes.

Not all Wilderness First Responder and EMT instructional curricula currently include instruction regarding hyponatremia, and wilderness medicine resources rarely include information about the illness.

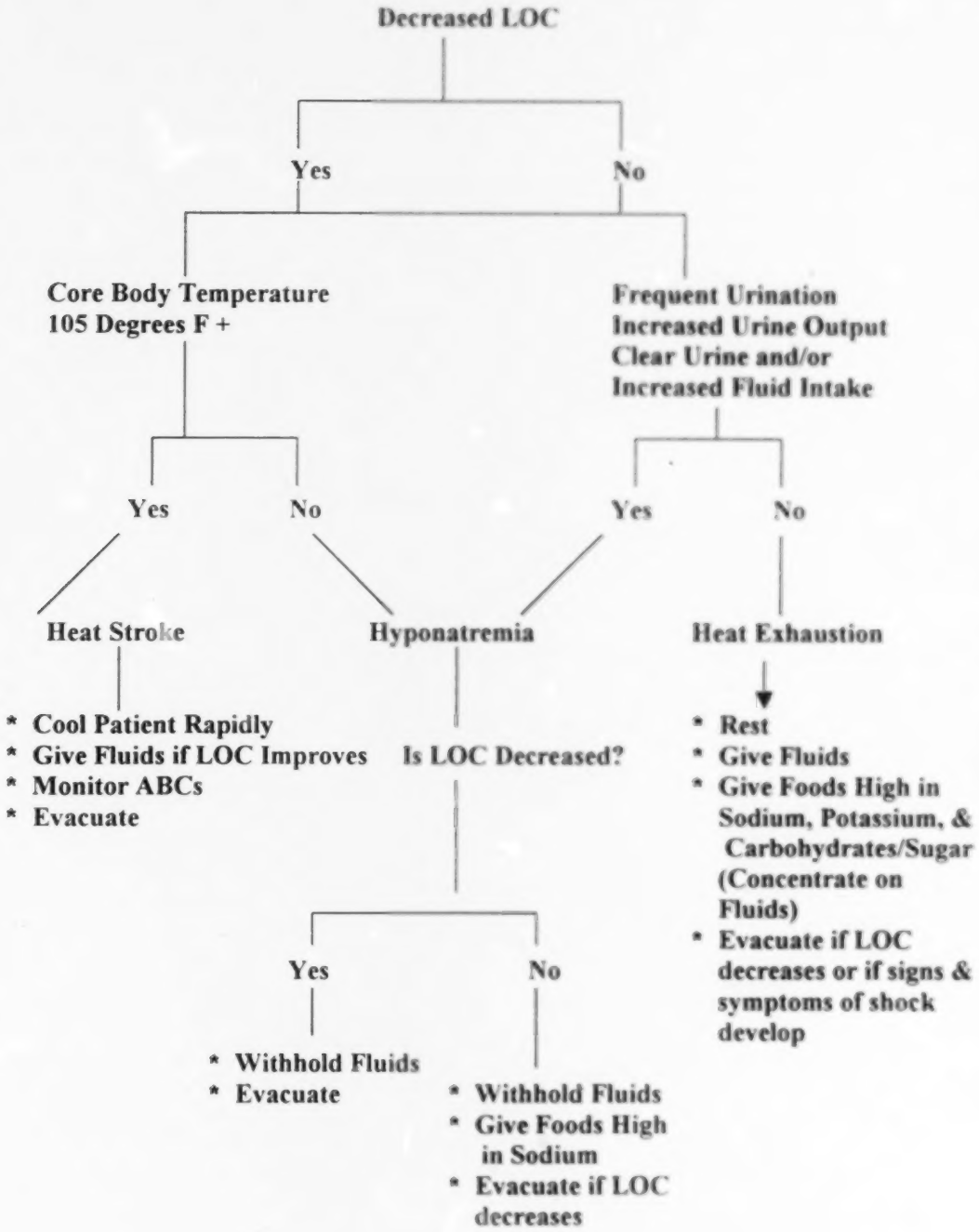
Given the high incidence of hyponatremia (one in ten cases of heat related illnesses) reported in the Grand Canyon study, it is important that wilderness medicine providers become more familiar with this illness.

The number of wilderness users as well as extreme adventure activities and endurance events has increased in recent years. It is likely that more cases of hyponatremia will be seen in the future. Proper assessment, treatment, and prevention are of paramount importance in the study, instruction, and practice of wilderness medicine.

Comparison of Signs & Symptoms
Heat Exhaustion, Heat Stroke, & Hyponatremia

Sign/Symptom:	Heat Exhaustion:	Hyponatremia:	Heat Stroke:
LOC	Normal or Decreased	Decreased	Decreased
RR	Increased	Increased or Normal	Increased
HR	Increased	Increased or Normal	Increased Early, Decreased Late
SCTM	Pale, Cool, Clammy	Pale, Cool, or Warm	Red, Hot, Dry (Classic),
BP	Normal or Decreased	Normal or Decreased	Decreased
Core Temperature	Normal or Decreased	Normal or Decreased or Increased	105 F+
Capillary Refill	Normal or Decreased	Normal or Decreased	Decreased
CNS Manifestations	Syncope	Seizures/Coma	Seizures/Coma
Ataxia	Yes	Yes	Yes
Dizziness	Yes	Yes	Yes
Headache	Yes	Yes	Sometimes
Parathesias	Yes	Yes	Sometimes
Thirst	Yes	Not Often	Yes
Chills	Yes	Yes	No
Orthostatic Hypotension	Yes	No	Yes (Classic) No (Exertional)
Urine Output	Decreased	Increased or Normal	Decreased (Classic) Normal (Exertional)
Frequency Urination	Decreased	Increased or Normal	Decreased (Classic) Normal (Exertional)
Frequency Urination	Decreased	Increased	Decreased (Classic) Normal (Exertional)
Clarity of Urine	Dark	Clear	Dark (Classic) Clear (Exertional)
Poor Skin Turgor	Sometimes	No	Yes (Classic) No (Exertional)
Nausea/Vomiting	Yes	Yes	Yes
Mucous Membranes	Dry	Moist	Dry (Classic) Moist (Exertional)

"Algorithm for the Assessment of Heat Illnesses"



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